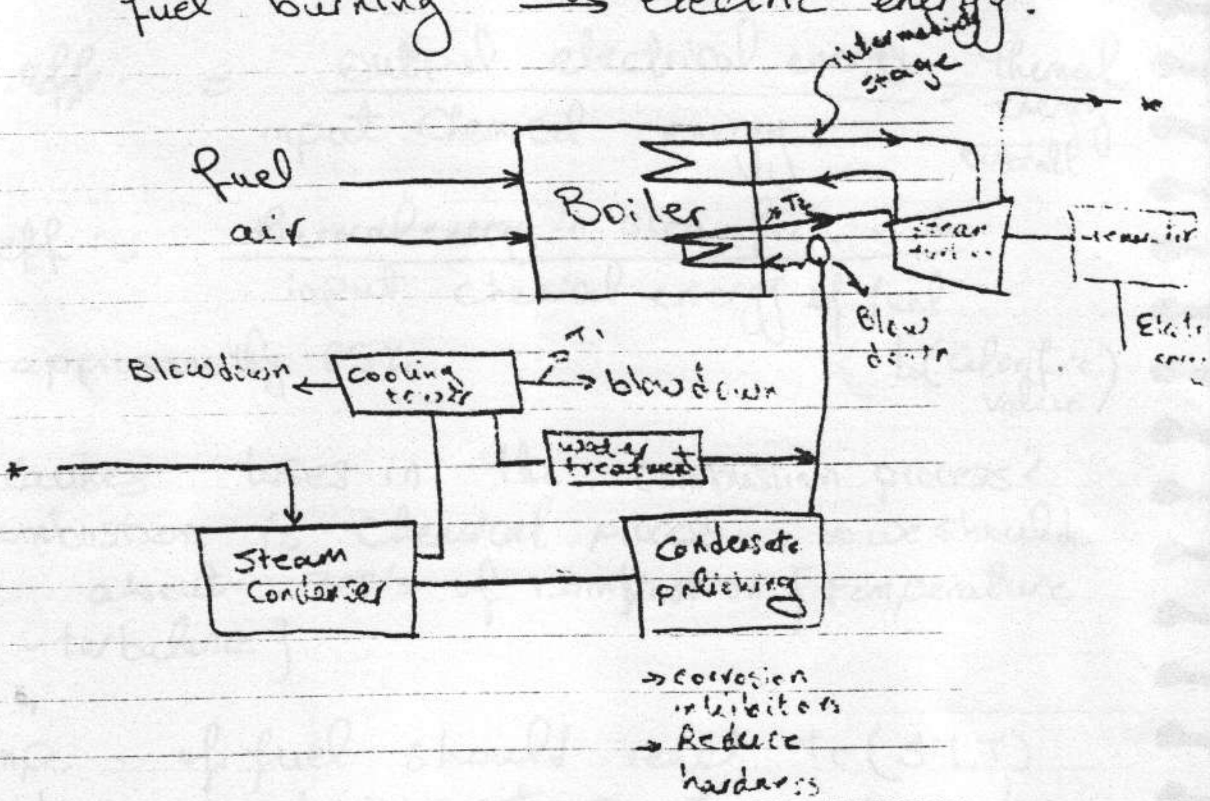
20/4/2008

lecture 8 Traditional Methods of Energy Conversion

* Solar energy $\xrightarrow{to}$ thermal energy
$\xrightarrow{to}$ Chemical energy ⇒ in photovoltaic cells
$\xrightarrow{to}$ electrical energy

* Convential method for energy conversion:
fuel burning $\xrightarrow{to}$ electric energy.



* Capacity of convential Power plant is 1000 MW.
* " " Nuclear " " " 2500 MW.
* effeciency of Conventional Power Plant don't exceed 40%.
* the Most common type of fuel used: Gas oil – Tineoil & N.G & Coal.
* we introduce excess air to ensure complete combustion
5% execess air for N.G. (5-15%) + Excess air
liquid fuels (20 – 25%)
Solid fuel (20 – 60%)

* But the use of excess air will reduce the efficiency because ~~its~~ inerts as Nitrogen take part of the thermal energy.

Boiler efficency $= \dfrac{\text{thermal energy obtained}}{\text{Chemical ener}}$

~~Boiler eff.~~ $= \dfrac{\text{output electrical energy}}{\text{input Chemical energy.}}$ = thermal energy overall

Boiler eff $= \dfrac{\text{thermal energy in steam from boiler}}{\text{input chemical energy of fuel}}$

↳ approximately 85%.

↳ (Calorific value)

What causes loses in the combustion process?

Combustion is Chemical process, so we should concern about 3T's of combustion [temperature - time - turbulance]

the temp. of fuel should reach to (SIT) spontaneous ignition temperature to make combustion occure. [As temp. obtained is higher than SIT is more better efficency.

Time :- fuel should have high residence time in the furnace to ensure complete combustion.

Turbulance :- represent the degree of Mixing of fuel with air so as Turbulance inc. the eff. of combustion is higher.

- for using gas fuels → easily mixed with air.
- " " liquid " → not easily mixed.

→ Burners (vaporizing — or — atomizer)

atomizer → liquid fuel exites. liquid tiny droplets

vaporizing ↓ fuel enter as liquid & exit as vapor
vaporize ↓ by taking latent heat from itself.

↳ atomizer type burners is used for large furnaces
air atomization
steam atomization

* Air atomization :- fuel is fixed with air before being atomized

→ Types of atomization :-
→ pressure atomization : the fuel is under high pressure where they exist as tiny droplets.

→ fluid atomization : → air atomization
↳ steam atomization.

Types of flames :-
→ luminaceous flame :- yellow color flame
↳ has high emissivity.
* is the amount of radiation emitted divided on the radiation from black body at same Temp.

*→ Non-Luminaceous flame :- Blue color flame
↳ has low emissivity

* As emissivity inc. than absorbitivity inc.

* Non-luminous flame is prefered because it high heat transfer, so it is used in furnaces to ensure higher efficiency.

* the luminanous flame contain C-particles (1 μm size) so it form colloidal solution ~~with~~ which has good immesivity. where the C-particles come from the incomplete combustion.

Requirments for perfect combustion:-

1- Introduction of fuel & Air with proper propotions.
2- Adequate mixing of fuel & Air.
3- Sufficient boiler heat transfer area.
4- 〃 combustion temperature.
5- Adequate fuel Residence time, to allow complete combustion.

Note:-

→ Part of HC's is not burned due to the small residence time in the ~~cy~~ ICE internal combustion engine.

⇒ In ICE the temp. inside the cylinder engine is not constant for every point.

* Cyclone burners :- the coal particles enter with centrifugal force to be mixed with air where the burnt ~~fuel~~ coal give hot gases which come from out.

* ~~Bulk~~ Pulvarized coal. مطحون
* stockers

* the amount of harmful efficiency (Disadvantage).
Pulvarized Coal > Cyclon > stockers.

* the ~~eff~~ thermal efficiency :- (Advantage)
Pulvarized coal > Cyclon > stockers

* Steam atomization is prefered for heavy fluid fuels as fuel.

* heat transfer of vapor ≈ = 10 times that of liquids.
= 100 times that of gases
→ thats why superheated steam is not used for heating, but saturated steam is used for heating.

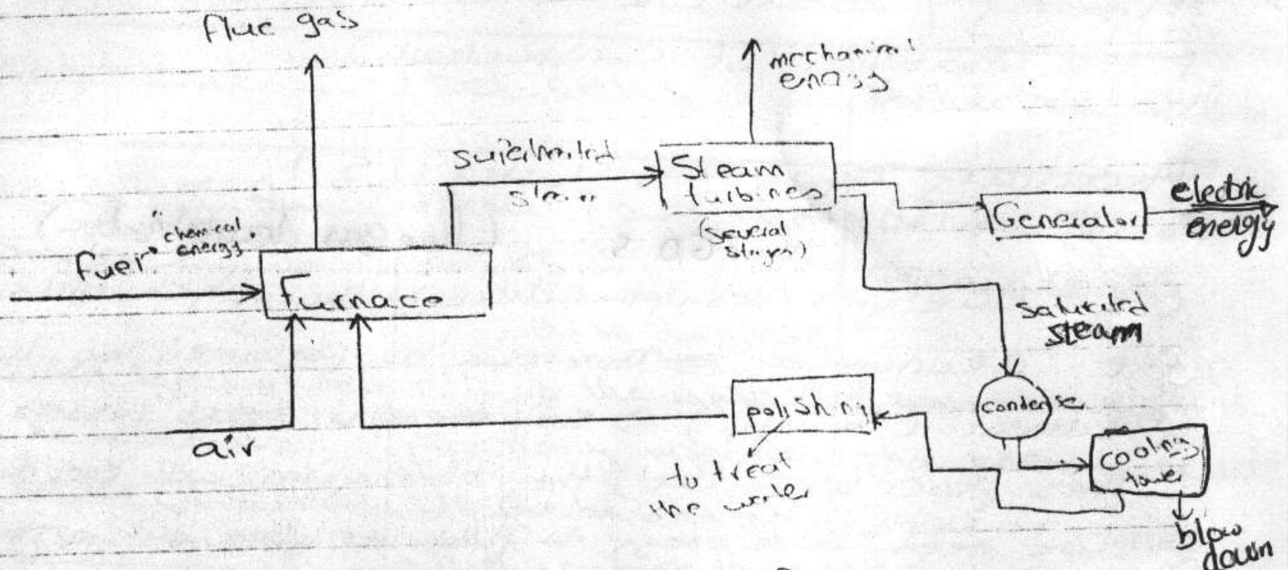
→ superheated steam first enter to steam turbin to use its high pressure to obtain Mechanical energy then its pressure decrease to have saturated steam to be used for heating purposes.

→ To improve efficieny of the combustion process so we use itermediate stage in the steam turbines.

* Carnot cycle efficency :- $\left[\frac{T_2 - T_1}{T_2}\right]$.

4-5-2008

lecture 9



* Source of heat losses in furnace

i) heat losses in stack gases   ii) heat losses in blow down

iii) heat losses from the furnace itself (according degree of insulation)

* Steam turbines

- According to the 2nd law of thermodynamics, we can't convert heat energy to mechanical energy without having (heat sink). So, we're limited with something similar to carnot cycle efficiency (Brayton cycles)

heat rejected

- carnot cycle theoretical } $\eta = \frac{T_2 - T_1}{T_2}$ → heat sink → heat source

T_2 : temp. of superheated steam , T_1 : temp. of ambient blow down

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$\boxed{ex}$ * The source of losses in furnace

heating excess air = 0.2 %

incomplete fuel combustion = 0.8 %

heating moisture in coal = 5 %

(Note : liq. and solid fuels mainly have moisture content

- Energy in the flue gases = 5%

Heat losses from the furnace itself = 0.9 %

*Heat rejected to cooling tower = 50.4 %

(This is from Carnot cycle η. As $T_2 \uparrow$, Carnot cycle efficiency $\uparrow$ ⇒ but we've limits for the temp. because of the material of construction)

Auxiliary equipments losses = 1.5 %

⇓

FGD system (flue gas desulphurization)

(ex: flue gas desulphurization system which follow the economizer ⇒ This can be performed by lime treatment ($Ca(OH)_2$) ⇒ so, there is heat losses in this process. But, the flue gases will cool down, and so we need more energy to push the gases out in the stack.

⇓ as the flue gases must go out with certain momentum)

Feed preparation = 0.45 %

N.G compressing

coal pulverizing

Pumps and fans in cooling towers = 0.8 %

electrostatic precipitators .8 % ⇒ To remove ash

Consumes high power energy

So, by multiplying all the above efficiencies, the overall η will be about **35%**]

Notes

gas turbines: mainly used in ships; drive the turbines optionally by the hot flue gases (high carnot cycle η) (but it's not practical because of the high cost of mat. of construction and the occurrence of hot corrosion which is very severe [b/c] Na_2SO_4 forms a molten layer on the surface

* Comparison between the different energy sources

Traditional	Fuel cells	photovoltaic cell
* Actual η from 30 – 40 %.	* Actual η can't exceed 60 – 65 %	* Actual η can't exceed 12 %
* several types of fuels can be used as fuel source (N.G, fuel oil, Coal	* H_2 (can be considered renewable) is the most practically used fuel. CH_4 can be used as a fuel if high temp fuel cells are more developed	* solar energy is the energy source
* for the same powerplant capacity, it's the cheapest w.r.t capital investment (the cost of (Kw)	* About 10 times the cost of traditional power plants (because of electrolyte, bipolar material.	* About 35 times (from (30 – 100 times) cost of traditional power plants
* Has the most Severe environmental impact — low incase of using N.G (as) fuel i) air emissions "NO_x, SO_x ii) ash "particulates mainly in coal" iii) waste water from blow down iv) noise pollution about 100 decibel	- noiseless as there is no moving parts - No local effect emissions (NO_x, SO_x, ...) - But, the global effect is considerable if CO_2 is formed	- noiseless as there is no moving parts - clean energy
* low flexibility where the capacity $<^{inc}_{dec}$, the effeciency will decrease → like the flame in bunzen burner.	* high flexibility (modular structure).	

Low flexibility make ~~[illegible]~~ limitations that the capacity must be always constant. So load leveling is needed where the excess energy produced is stored in batteries to be used on need.		
AC is produced which is an advantage	* DC is produced	* DC is produced